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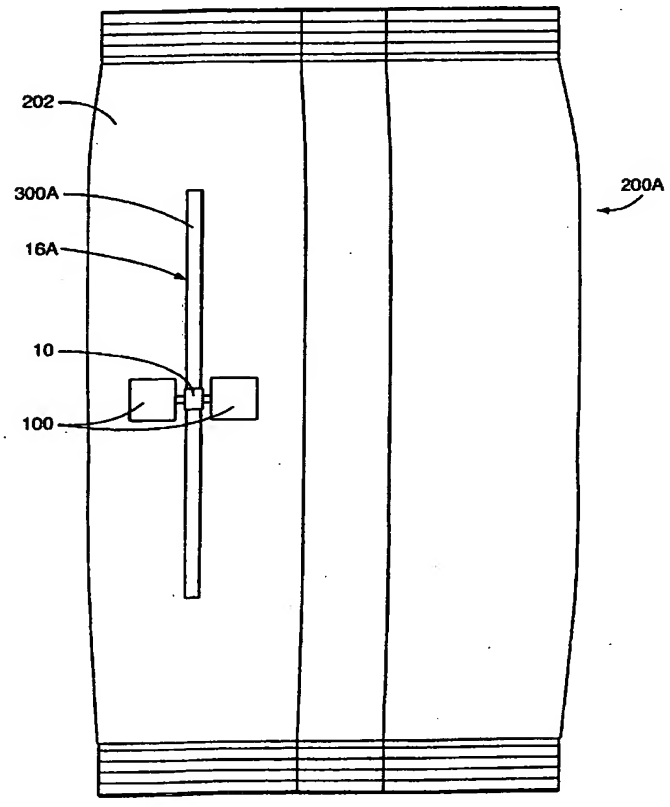
(54) Title: WIRELESS PALLET COMMUNICATION DEVICE AND METHOD



(57) Abstract: The invention relates to a wireless communication device that is placed on a pallet to provide wireless communication, in the form of information, concerning the pallet and/or containers being stored and/or transported on the pallet. Information may include any information about the containers, such as contents, "born=on" date or date of manufacture, lot number, expiration date, etc. The pallet contains studs that are fitted with one or more pallet rails. The wireless communication device is placed inside a pallet rail clip that is securely placed on a pallet rail. The wireless communication device may be placed across the pallet rail, using the slot in the pallet rails as a slot antenna. Pallets containing a wireless communication device may be tracked through a facility, such as a manufacturing or distribution facility.

WO 02/07084 A1

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Wireless Pallet Communication Device and Method

The present invention relates to an apparatus, system and method of pallet communication with a pallet containing items, using a wireless communication device.

It is often desired to wirelessly identify, track, and/or provide information about items of manufacture, such as containers, packages, and the like. One method of tracking and providing information about items is to attach a wireless communication device, such as a radio frequency identification (RFID) transponder or other identification device, to the item. The information communicated by the wireless communication device concerning items may include identification number, expiration dates, "born on" dates, lot numbers, manufacturing information, and the like.

Items are often stored and/or transported on pallets during manufacturing and/or distribution. One method of identifying, tracking and providing information concerning items contained on a pallet is to attach a wireless communication device to the individual items on the pallet. However, communication collisions may occur if a pallet contains items having wireless communication devices that communicate at the same frequency. Providing a wireless communication device per item on a pallet may also be quite expensive.

Pallets often include more than one item, but these items may be a plurality of the same type of item having the same information characteristics, such as date of manufacture, lot number or other information that may be communicated in a single communication from a single source. Therefore, a wireless communication device may be provided on a pallet, instead of per item on a pallet. In this manner, information is communicated about the items on the pallet from the pallet instead of each individual item.

Therefore, it is desirable to provide a wireless communication device for a pallet to communicate information about the pallet and/or items on the pallet.

The present invention relates to a wireless communication device associated with a package, container, or other item, or a device that transports a package, to communicate information concerning the package, container or item, or transport device. One type of transport device is called a "pallet." A pallet is a tray or other surface that is used to store and/or transport containers.

A wireless communication device is provided on transport device and/or container that contains a control system, communication electronics, memory, and an antenna. The wireless communication device may contain a sensor to sense environmental conditions surrounding the wireless communication device. The wireless communication device contains one or more tabs constructed out of conductive material. The tab(s) serve as both a pole antenna and attach the wireless communication device to a slot, thereby forming a slot antenna.

In one embodiment, the wireless communication device is placed on a pallet that is designed to hold items during storage and/or transport. The pallet is fitted with one or more pallet rails that are inlaid securely into studs on the pallet. A wireless communication device is attached inside a pallet rail clip, and the pallet rail clip is placed securely on a pallet rail. The wireless communication device may either communicate information about the pallet itself, or containers stored and/or transported on the container, using a pole antenna or slot antenna.

In another embodiment, the wireless communication device is attached to a pallet rail on a pallet. The pallet rail has a slot formed by a backplane grove with protruding ridges. The wireless communication device is coupled across the slot to

form a slot antenna. The wireless communication device may couple to the slot using a feed line, or using one or more conductive tabs coupled to the wireless communication device. An optional frame may be attached to the slot to bound the length of the slot. The wireless communication device may also be grounded to a ground plane on the pallet rail.

In another embodiment, pallets are tracked as they move through a manufacturing and/or distribution facility. Pallets may contain items with information that is communication to interrogation readers at different points during transport. This information is collected by a central control system. The central control system may make certain decisions based on information received from pallets.

In another embodiment, the wireless communication device is a transponder that is interrogated by an interrogation reader for communication purposes. The wireless communication device is attached to package that may be constructed out of a conductive material, such as foil packaging used for food or liquid.

The tab(s) attach to the surface of the package. In one embodiment, the tab(s) are attached to the surface of a package. In a different embodiment, the tab(s) are reactively coupled to the surface of the package through a dielectric material. The dielectric material can be an adhesive material placed on the tab(s) to attach the wireless communication device to a package.

In another embodiment, the tab(s) form a pole antenna to communicate in a first mode at one frequency, and the tab(s) are attached across a slot in a package to communicate in a second mode at a second frequency. One tab is used in one embodiment to form a monopole type antenna, and two tabs are used in another

embodiment to form a dipole antenna. In another embodiment, the tab(s) can be varied in shape and size to adjust to surfaces that vary in form.

In another embodiment, the width of the slot is varied to match the impedance of the slot to the impedance of the wireless communication device. Another embodiment uses a matching network to match the impedance of the slot to the impedance of the wireless communication device.

In another embodiment, the wireless communication device operates inside packaging constructed out of a conductive material, such a foil, and uses a slot cut in the packaging to form a slot antenna. Another embodiment forms a slot inside the packaging by placing a non-conductive material, such as a dielectric, in between a sealed portion of the package. The wireless communication device attaches to the slot to form a slot antenna.

In another embodiment, the wireless communication device reacts to the opening of the package and communicates such event and/or stores it in memory. In another embodiment, the wireless communication device uses a sensor to sense the environment and to detect when the package is opened. A second seal may be provided in the package so that the wireless communication device inside the package does not come into contact with the contents of the package.

The wireless communication devices can be placed in a carrier or support, divided into portions, with one device per carrier portion during manufacturing. The carrier or support may be a conductive material, whereby one or more conductive tabs are formed as part of the carrier. The wireless communication device is attached to the carrier thereby attaching the wireless communication device to one or more conductive tabs. The carrier or support is placed proximate to packages during manufacture, and

the wireless communication devices are attached to the packages by stamping the devices onto the packages either across a slot cut into the packages, or to a slot formed by the package.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram illustrating communication between a wireless communication device and an interrogation reader;

Figure 2 is an illustration of the wireless communication device with slot antenna on a foil food package;

Figure 3A is a schematic top view diagram of the wireless communication device with connecting tab devices containing a dielectric, adhesive material;

Figure 3B is a schematic diagram side view diagram of the wireless communication device in Figure 3A;

Figure 3C is a schematic diagram of the wireless communication device having its own slot;

Figure 4 is a schematic diagram of the wireless communication device attached across a slot to form a slot antenna;

Figure 5A is a schematic diagram of the wireless communication device having a slot antenna of a particular width to match the impedance between the wireless communication device and the slot;

Figure 5B is a schematic diagram of the wireless communication device illustrated in Figure 6B with a slot of different width;

Figure 6 is a schematic diagram of a circularly polarized slot antenna;

Figure 7 is a schematic diagram of another type of packaging containing a wireless communication device;

Figure 8A is a schematic diagram of the wireless communication device having a slot antenna formed by a foil package closing;

Figure 8B is a schematic diagram of the wireless communication device illustrated in Figure 8A with the foil package having an additional seal below the wireless communication device;

Figure 9 is a flowchart illustrating the operation of the wireless communication device when sensing to detect its presence outside of a package;

Figure 10 is a schematic diagram of a wireless communication devices mounted on a carrier or support for stamping into packages in an assembly line;

Figure 11 is a schematic diagram illustrating a pallet holding containers and containing a wireless communication device;

Figure 12A is a schematic diagram illustrating a pallet rail clip;

Figure 12B is a schematic diagram illustrating a pallet rail clip mounted into the edge of a pallet rail;

Figure 12C is a schematic diagram illustrating a pallet rail clip containing a wireless communication device coupled across a slot to form a slot antenna;

Figure 13A is a schematic diagram illustrating a wireless communication device attached to a pallet rail and coupled across a slot in the pallet rail to form a slot antenna;

Figure 13B is a schematic diagram illustrating a wireless communication device attached to a pallet rail and coupled across a slot, bounded in length by a foil frame, in the pallet rail to form a slot antenna;

Figure 14A is a schematic diagram illustrating a wireless communication device attached to a pallet rail and directly coupled to a slot in the pallet rail to form a slot antenna;

Figure 14B is a schematic diagram illustrating a wireless communication device attached to a pallet rail and reactively coupled to a slot in the pallet rail to form a slot antenna; and

Figure 15 is a schematic diagram illustrating a tracking and information system to track pallets having a wireless communication device.

The present invention is directed to a device, system and method of attaching a wireless communication device, such as a radio frequency identification device (RFID) to a package to communicate information about the package or a container, or a transport device that stores and/or transports such packages or containers, including a pallet. The package may be an individual package containing specific contents, or an individual, exterior package containing a group of additional, interior individual packages. The word "package" and "container" are used interchangeably herein to describe a material that houses contents, such as goods or other individual packages, and equivalents structures. The present invention should not be limited to any particular meaning or method when either "package" or "container" is used.

Transponder Communication

As illustrated in Figure 1, the invention includes a wireless communication device 10 for electronic communication. Some wireless communication devices 10 have both a transmitter and receiver. Other wireless communication devices 10, known in the art as "transponders," are interrogated by interrogation reader 50, whereby the transponder communicates back by altering field 58 containing interrogation signal 56.

This description refers to the terms "transponder" and wireless communication device 10 interchangeably, and the use of the term transponder is not intended to limit the type of wireless communication device 10 applicable to the present invention. Wireless communication devices 10 are available that communicate at various frequencies, including UHF and VHF. One embodiment of the present invention uses a wireless communication device 10, also called a "transponder," that is a passive radio-frequency device with the ability to rectify incoming radio energy and provide power to power the device for communication and operation. The invention is also applicable to active devices that have their own power source for communications. It should be readily understood to one of ordinary skill in the art that there are many other different types of wireless communication devices 10 that allow electronic communication and thus the present invention is not limited to any one particular type.

Transponder 10 includes a control system 12 and communication electronics 14. Transponder 10 may also contain memory 18 for storage of information to be communicated to an interrogation reader 50. Alternatively, transponder 10 may store information such as an identification number or other information by using diodes, dip switches or some other like circuitry in lieu of erasable memory 18. Antenna 16 is provided to receive the interrogation signal 56 from interrogation reader 50. Antenna 16 may be either external to or internal to transponder 10. The particular type and location of antenna 16 will depend on the operating frequency of transponder 10 and the particular design desired. Transponder 10 may also be connected to sensor 20 for sensing ambient or environmental information surrounding transponder 10, package 200 containing transponder 10, or the contents of container 200. One example of sensor 20 may be a quartz crystal resonator like that described in U.S. Patent No. 5,922,550. A

quartz crystal resonator detects analytes that may be present in food. Analytes include, but are not limited to, microorganisms such as bacteria, yeasts, fungi and viruses.

Antenna 16 receives signal 56 through the radiated interrogation field 58. Antenna 16 passes received signals 56 to communication electronics 14. Communication electronics 14 contain circuitry necessary to interpret signal 56 from field 58 and to further communicate the interpreted signal to control system 12. Control system 12 is an integrated circuit, printed circuit board, or other type of microprocessor or micro-controller electronics that controls the operations of the transponder 10. Control system 12 is connected to communication electronics 14 to communicate and receive transmissions. Control system 12 is also connected to memory 18 for storing and retrieving information. Control system 12 may further include a clock (not shown). Control system 12 determines if any actions are needed in response to the communications received from communication electronics 14.

Figure 1 also depicts how communication is achieved with transponder 10 using an interrogation reader 50. Interrogation reader 50 contains interrogation communication electronics 52 and an interrogation antenna 54. Interrogation reader 50 communicates with the transponder 10 by emitting an electronic signal 56 modulated in a frequency by interrogation communication electronics 52through interrogation antenna 54. Interrogation antenna 54 may be any type of antenna that can radiate signal 56 through a field 58 so that a compatible device, such as transponder 10, can receive such signal 56 through its own antenna 16. Field 58 could be electro-magnetic, magnetic, or electric. Signal 56 is a message containing information or a specific request for the transponder 10.

When antenna 16 is in the presence of field 58 emitted by interrogation reader 50, communication electronics 14 are energized by signal 56, thereby energizing transponder 10. Transponder 10 remains energized so long as antenna 16 is in the field 58 of interrogation reader 50. Communication electronics 14 demodulates signal 56 and sends the message containing information or request to control system 12 for appropriate actions. For example, the request may be for transponder 10 to communicate its identification, or information about a material or container containing transponder 10, such as date of manufacture, place of manufacture, and/or lot number. The message may also be a request for information regarding ambient or environmental measurements sensed by sensor 20.

Another description of a transponder 10 that may be used with the present invention is located in U.S. Patent No. 5,347,280. Transponder 10 is one type of wireless communication device. Other types of wireless communication devices 10 may be used with the present invention. For instance, transponder 10 may have a transmitter that can send information to interrogation reader 50 without having to alter signal 56. Transponder 10 may contain a battery to power the transmitter, or an energy storage unit that is charged by energy received from signal 56 when wireless communication device 10 is in the range of field 58. It is readily understood to one of ordinary skill in the art that there are many other types of wireless communications devices and communication techniques than those described herein, and the present invention is not limited to a particular type of device, technique or method.

Transponder 10 may be attached on any type of device or container, or transport device that stores and/or transports a device or container, to identify and communicate information concerning the device or container. For example, transponder 10 may be

attached to a transport device, such as a pallet. Transports device may be valuable. Tracking and identification of transport devices may be important to ensure minimization of loss or misplacement of such transport devices.

Transponder 10 may also be attached to a package, and may contain identification information and other information about the package and/or its contents, such as identification number, date of manufacture or "born on" date, expiration date for sale or consumption, lot number, etc. For example, transponder 10 may be attached to a wine bottle and contain information concerning the type of wine and its ingredients or make up, the date of manufacture, and expiration dates. Transponder 10 may be attached to virtually any device or container conceivable.

The present invention relates to attachment of transponder 10 to a transport device and/or a variety of containers 200 in a variety of different manners to achieve wireless communication. One embodiment of the present invention relates to attachment of transponder 10 on a transport device called a "pallet," described later and in Figures 11 - 15. The description of transponders 10, antennas 16, slots 300, packages 200 or containers 200, tabs 100, and all other elements described herein are equally applicable to all embodiments in this invention.

Slot Antenna Communication Embodiments

Figure 2 illustrates transponder 10 attached to a food package 200A. Antenna 16 can either be a slot antenna 16A, as illustrated in Figure 2, or a pole antenna 16B, as illustrated in Figures 3A and 3B). A slot 300A is provided in package 200A to provide slot antenna 16A. Package 200A includes a surface 202. At least one tab 100, made out of conductive material, such as a metallic material, is attached to transponder 10, and more particularly to communication electronics 14 inside transponder 10. Two or

more tabs 100 may also be attached to transponder 10 to provide antenna 16. The use of "tab" is used in singular and plural herein, and reference in either form is not intended to limit the invention to only one tab 100, or more than one tab 100.

Tabs 100 are attached to slot 300A to form a slot antenna 16A. For the purposes of this specification, the word "attached" is used generically to mean either attached directly or coupled to slot 300A. The tabs 100 may either be attached on slot 300A or proximate to slot 300A. Tabs 100 may also serve as pole antenna 16B. Tabs 100 may also be constructed by applying a conductive fluid (e.g. conductive ink) onto surface 202.

The present invention can also be used with transponder 10 containing one tab 100 to form either slot antenna 16A or pole antenna 16B. One tab 100 can be used to form pole antenna 16B in the form of antenna having monopole-like radiation pattern. If one tab 100 is used to form slot antenna 16A, tab 100 is attached to slot 300A, and transponder 10 is attached, in the form of grounding, to slot 300A to form a ground plane. Using one tab 100 as a slot antenna 16A will create a monopole-like radiation pattern.

If surface 202 is constructed out of a conductive material, it may be advantageous to use tabs 100 to create slot antenna 16A rather than pole antenna 16B. Examples of conductive surfaces 202 include food foil packaging, wine bottles cork foil, jewelry, watches, cigar label foil, and alcoholic bottle foil labels. If tabs 100 are attached on a conductive surface 202 without forming slot antenna 16A, the radiation pattern of the resulting pole antenna 16B, created by tabs 100 may not be properly tuned to the operating frequency of transponder 10. Factors such as the conductivity and surface area of surface 202 affect the radiation pattern of a pole antenna 16B formed by

tabs 100 when tabs 100 are attached to surface 202. Packages 200 vary greatly in size, shape, and area. It is desirable for transponder 10 and tabs 100 to be manufactured such that transponder 10 operates at a desired frequency when using tabs 100 as a pole antenna 16B, regardless of the particular characteristics of package 200A.

Packages 200 that are constructed out of conductive material, such as foil, containing transponder 10 inside container 200 cannot use a pole antenna 16B. The radiation pattern of pole antenna 16B is shielded by the conductive material. Therefore, another reason for using tabs 100 to create a slot antenna 16A rather than a pole antenna 16B may be so that packages constructed out of conductive material and containing transponder 10 inside container 200 can effectively communicate desired information wirelessly.

If tabs 100 are attached on surface 202 that are not conductive, tabs 100 can function at the desired operating frequency as a pole antenna 16B, regardless of the characteristics of container 200. If two tabs 100 are used, the tabs 100 serve as a dipole antenna 16B. One tab 100, instead of two tabs 100, may also be used to serve as antenna 16, thereby creating a monopole type radiation pattern as previously described above. A ground plane may be provided between transponder 10 and surface 202 such that communication electronics 12 is attached to surface 202 to from a ground. In summary, tabs 100 can serve to provide either a pole antenna 16B or slot antenna 16A depending on container 200 and its characteristics.

Figures 3A, 3B and 3C illustrate on embodiment of transponder 10 in more detail. Figure 3A illustrates transponder 10 from a top view perspective. Tabs 100 are made out of a conductive material. For example, tabs 100 may be constructed out of metal, such as aluminum or copper. Figure 3B illustrates transponder 100 from a side

view perspective. Tabs 100 may either be attached directly to surface 202 or coupled to surface 202, by placing tabs 100 on an optional dielectric adhesive material 102 that is attached to surface 202. Use of adhesive material 102 may be necessary to attach transponder 10 to surface 202. If transponder 10 is attached on container 200 without a slot 300, such that tabs 100 act as a dipole antenna 16B, a dielectric material 102 may be attached between the surface 202 and tabs 100 so that the radiation pattern of the dipole antenna 16B is not affected by container 200. If dielectric material 102 is used, tabs 100 are reactively coupled, rather than directly connected, to surface 202. One tab 100, instead of two tabs 100, may also be used to serve as antenna 16, creating a monopole type radiation pattern. If transponder 10, with tabs 100, is attached across slot 300 on a conductive surface 202, a slot antenna 16A is formed for antenna 16.

Transponder 10 may be attached to slot antenna 16A as part of its construction, instead of using a slot 300A created in container 200 to form slot antenna 16A. Figure 3C illustrates slot 300A as a rectangular, conductive material 250 having a hollow portion cut out to form an inner, non-conductive portion 252. Tabs 100 are attached to non-conductive portion 252. Slot 300A may be constructed in any shape desired so long as slot 300A is constructed out of a conductive material 250 that contains an inner non-conductive portion 252. This inner, non-conductive portion 252 can be air, formed by a cut out as illustrated in Figure 3C, or can be formed by placing a non-conductive material, such as plastic, onto or inside conductive material 250. Conductive material 250 may also contain an adhesive 102, so that slot 300A, with transponder 10 attached, can be easily attached to container 200. It may be desirable to provide slot 300A as part of transponder 10, instead of container 200, insofar as this eliminates the requirement to create slot 300A in container 200 as part of the construction of container 200. For

example, it may be impractical or impossible to provide slot 300A in container 200, but still desirable to attach transponder 10 to container 200 using slot antenna 16A. As an additional advantage of this embodiment illustrated in Figure 3C, container 200 may be constructed out of non-conductive material, since slot 300A is provided as part of transponder 10.

Figure 4 illustrates transponder 10 with tabs 100 acting as both a pole antenna 16B and slot antenna 16A. Slot 300A is provided by cutting out a portion of conductive surface 202. The length of tabs 100 define the operating frequency of antenna 16 if tabs 100 are configured to act as a pole antenna 16B. In one embodiment, tabs 100 are each $\lambda/4$ in length, or 30.6 millimeters each, to form a dipole antenna 16B with a total length of $\lambda/2$ and an operating frequency of 2.45 GHz.

As previously discussed, tabs 100 may also serve to form slot antenna 16A, if attached across slot 300A in conductive surface 202. Slot 300A length defines the operating frequency of slot antenna 16A. In one embodiment, slot 300A length is $\lambda/2$ or 164 millimeters, so that transponder 10 operates at a frequency of 915 MHz. More information on slot antennas 16A, and their operation is described in U.S. Patent No. 4,975,711.

In this manner, transponder 10 has two antenna 16 configurations that are capable of communicating at two frequencies. If transponder 10 is capable of communicating at two different frequencies, as discussed above, pole antenna 16B and slot antenna 16A can be configured to communicate at different frequencies as well, enabling transponder 10 to effectively communicative at both frequencies. This arrangement provides an advantage in particular if 915 MHz is a desired frequency. 915 MHz is frequently used as an operating frequency for electronic communication in

the United States, but 2.45 GHz is frequently used outside the United States. Therefore, providing transponder 10 with the capability of communicating at both 915 MHz and 2.45 GHz is advantageous so that transponder 10 can be used for applications in both the United States and abroad. However, if this dual capability is not required, transponder 100 can be configured to operate solely using pole antenna 16B or slot antenna 16A.

Figures 5A and 5B illustrate transponder 10 attached across slots 300A, 300B of varying widths. The width of slots 300A, 300B affects the impedance of slots 300A, 300B. For example, a wider slot 300A, illustrated in Figure 5A, may have a higher impedance than the narrower slot 300B, illustrated in Figure 5B. Varying slot 300 width varies the impedance of slot antenna 16B to maximize antenna 16 strength. It is desirable to match the reactance of slot 300 to the impedance of transponder 10. In the one embodiment, slot antenna 16A has a fairly low impedance. Therefore, it is desirable to transform slot 300 impedance so as to match the impedance of transponder 10, thereby maximizing energy transfer between transponder 10 and slot 300 and maximizing the strength of the radiation pattern emitted by slot antenna 16A. Matching the impedances also minimizes reflection in the radiation pattern of slot antenna 16A. Transponder 10 may comprise include more than one layer, including conductive, dielectric and magnetic materials, such as ferrites, to introduce inductance, thereby aiding modification of the characteristics of surface 202 for impedance matching purposes.

In addition to the composition of transponder 10, the area of tabs 100 affect the impedance of transponder 10. As discussed above, it is desirable to match the impedance of transponder 10 and slot 300. Tabs 100 can also be varied to ensure

optimal coupling to surface 202. The impedance of slot 300 may be varied for matching purposes by modifying relevant characteristics of surface 202. For example, a conductive package for food (e.g. foil) may have a surface 202 that is variable in width, dielectric or metallic characteristics. Capacitance of tabs 100 may be taken into consideration for impedance matching when attaching tabs 100 to a particular surface 202. The capacitance of tabs 100 affects the impedance of transponder 10. The total volume of tabs 100 (surface area times thickness) affects their capacitance. Tabs 100 are similar to parallel plate capacitors in series with wireless communication device 10. The larger the volume of tabs 100, the larger their capacitance. It is therefore desirable to design and construct tabs 100 with a capacitance that is commensurate with surface 202 to match impedance of transponder 10 and slot 300A for optimal performance.

An impedance matching network may also be used to match slot 300 impedance to transponder 10 impedance, as discussed in U.S. Patent Application No. 09/536,334, entitled "Remote Communication Using Slot Antenna," assigned to assignee of the present invention.

Figure 6 illustrates two slots 300A, 300B in surface 202 that are substantially perpendicular to each other, with tabs 100 attached across slots 300A, 300B. Tabs 100 are attached to slots 300A, 300B at vertical angles, but tabs 100 can also attach to slots 300A, 300B adjacent to each other. This structure creates a circularly polarized slot antenna 16B. Tabs 100 are attached to each of slots 300A, 300B. The length of first slot 300A, a, is slightly shorter $\lambda/2$. The length of second slot 300B, 'b', is slightly greater than $\lambda/2$. Slots 300A, 300B provide antennas 16 that can be considered resonant circuits, with their associated phase delay at the operating frequency of ± 45 degrees to each other. This causes transponder 10 to receive efficiently radiation in more than one

dimension and, specifically, in the form of a circular pattern so that the orientation of transponder 10 on surface 202 is somewhat irrelevant for communication.

Figure 7 illustrates another type of container 200 containing transponder 10 called a gum-stick package 200B. Gum-stick package 200B is configured to contain gum sticks (not shown). Gum-stick package 200B is constructed out of a conductive material. Gum sticks are wrapped in their own individual foil wrappers and are placed inside paper non-conductive wrappings 900 contained inside gum-stick package 200B. Parts of the non-conductive wrappings 900 touch or couple to the interior of gum-stick package 200B. Such attaching or coupling provides a slot antenna 16C as previously discussed, where the non-conductive wrappings provide slot 300C and gum-stick package 200B inside provides the surrounding conductive material. Figure 7 illustrates transponder 10 placed inside gum-stick package 200B. Tabs 100 are attached to slot 300C, as previously described, to provide communication. Again, tabs 100 are also capable of operating as a pole antenna 16B. Gum-stick package 200B could also be a cigarette package. Again, package 200B is coupled to a slot 300C, formed by conductive material of the package 200B in addition to an internal non-conductive portion internal to package 200B, to form slot antenna 16C.

Figures 8A and 8B illustrate particular manners in which transponder 10 is placed inside package 200C. Figure 8A illustrates transponder 10 located inside the top of package 200 where package 200C opens and seals in a pouch-like fashion. Transponder 10 and tabs 100 are placed inside a top 302 of package 200C. The inside surface 202 of package 200C is a conductive material, such as a foil, including the sides of package 200C that come together when food package 200A is closed and sealed. As discussed previously, it is desirable to configure transponder 10 to communicate using a

slot antenna 16D when transponder 10 is inside a package 200C constructed out of conductive material. In this embodiment, slot antenna 16D is not formed by cutting out a portion of surface 202, but rather by inserting a non-conductive material 302, such as a dielectric, inside package 200C at the top to form a seal 302 where the sides come together. In this manner, a slot 300D is formed by the separation of the conductive material of inner surface 202 when the sides of package 200C, are closed and sealed. Such a method of placing a transponder 10 inside food package 200A may be advantageous where it is desired to protect transponder 10 from theft, tampering or other unwanted elements.

Placing transponder 10 inside package 200C may also be useful to indicate if package 200C has been opened, and, therefore, possibly contaminated. Packages 200 that contain food for consumption or medical devices and equipment requiring sterility are also possible applications. Transponder 10 is placed inside package 200C, as previously discussed and illustrated in Figures 8A and 8B.

One embodiment to detect the opening of package 200C is to provide tabs 100 constructed out of a material that reacts to ambient air. When package 200C is opened, tabs 100 become exposed to the outside air. If tabs 100 are constructed out of a material that looses its conductivity when exposed to air, transponder 10 cannot be interrogated and/or communicate as effectively, since tabs 100 are attached to slot 300D to provide a slot antenna 16D for communication. Thus, lack of communication or degredated communication can be used as an indicator that package 200C has been previously opened.

Figure 8B illustrates an embodiment where it is not only desirable to place transponder 10 inside package 200C, but also to separate transponder 10 from the

contents of package 200C. In this embodiment, a second seal 304 is provided in package 200C. Transponder 10 is located in first seal 302 as previously described above. Transponder 10 is still exposed to air when package 200C is opened, but transponder 10 is not contained in the same portion of package 200C where the contents of package 200C are contained. This embodiment may be desirable when the contents of package 200C are food or liquid for consumption, or other materials where it is not safe or desirable for transponder 10 to come in contact with the contents of package 200C.

Another embodiment uses sensor 20 to determine when package 200C is opened. Sensor 20 may be any type of sensor that senses elements of air in the area on the outside of package 200C. Air contains oxygen, nitrogen and other gaseous elements. For instance, sensor 20 may be an oxygen sensor, including the sensor described in U.S. Patent No. 6,027,622. Further, sensor 20 can be any type of sensor that senses an environmental factor, such as a gaseous element, that is not contained inside package 200C when sealed with transponder 10 therein.

Figure 9 illustrates a flow chart of one embodiment of transponder 10 using sensor 20 to determine if food package 200A has been opened. The process starts (block 400) and control system 12 receives signals from sensor 20 indicating a reading (block 402). The control system 12 determines if reading from sensor 20 indicates that food package 200A is opened (decision 404). If package 200C is opened, control system 102 stores this event in memory 18 to communicate it the next time transponder 10 is interrogated by interrogation reader 50 (block 406). If transponder 10 has transmission capability, transponder 10 may transmit the event of package 200C being open immediately. The process then ends (block 408). Alternatively, if it is determined

that the package 200C is not open (decision 404), transponder 10 takes another reading from sensor (block 402), repeating the process again.

Figure 10 illustrates an embodiment of providing transponders 10 for stamping onto packages 200 in an assembly line or other manufacturing capacity. A carrier 700 is provided that contains individual slides 702. Carrier 700 may be a film or other similar type of material. Transponder 10 is manufactured and placed on carrier 700 during assembly, whereby each portion 702 contains one transponder 10. The carrier 700 is constructed out of a conductive material. Carrier 700 may also contain, as part of its construction, one or more conductive tabs 100. Since carrier 700 is a conductive material, tabs 100 are conductive. Transponder 10 is placed onto carrier during assembly and connected to tabs 100 formed in carrier 700. Later during the manufacture or assembly process, transponder 10 is placed onto packages 200. Carrier 700 may have perforations 704 for movement by a machine in an assembly line when mounting transponders 10 to portions 702. Transponder 10, attached to one or more tabs 100 formed in carrier 700, is stamped onto packages 200 in an assembly line by placing carrier 700 proximate to packages 200. Carrier 700 is stamped in such a manner that transponder 10, with tabs 100 attached, are placed onto packages 200. When desired, a stamping process places carrier 700 and a particular portion 702 in contact with package 200 so that transponder 10 is more easily attached to package 200. Package 200 may contain slot 300, whereby transponder 10 is stamped across the slot 300. Transponder 10, tabs 100, or both, may also contain an adhesive 102, as previously discussed, so that transponder 10 attaches to package 200 securely.

Figure 11 illustrates another embodiment of the present invention, whereby transponder 10 is attached to a pallet 720. Pallet 720 is a tray or platform used for

moving materials, such as packages 200D, containers 200D, or other materials. Pallets 720 are often used in conjunction with a forklift in a manufacturing, distribution and/or storage facility for lifting and moving materials. In one embodiment, pallet 720 is an air-cargo pallet that is used to carry and transport containers 200D and/or materials 200D onto and off of aircraft.

Pallet Rails and Clips

A cable 724 or other cabling material may be used to secure containers 200D to pallet 720. One method of securing containers 200D to pallet 720 is to secure cable 724 onto one or more pallet rails 726. A pallet rail 726 is a rail that is inlaid into a studs 72 contained in pallet 726, and fits securely within stud 725. Pallet 726 may contain studs 725 on one or more sides. Pallet rail 726 may be constructed out of a conductive material, such as steel or aluminum. Pallet rail 726 has ridges 727 that protrude from backplane 733 to allow cable 724 or other fittings to be secured to pallet rail 726 and thereby secure to pallet 726. Pallet rail 726 may be part of the natural construction of pallet 726, or pallet rail 726 may be attached as a separate device to pallet 720.

One embodiment of the present of invention encompasses attachment of transponder 10 to a pallet rail clip 728, so that information concerning pallet 720 and/or containers 200 on pallet 720 may be wirelessly communicated. An example of a pallet rail clip 728 is illustrated in Figure 12A. A pallet rail clip 728 is designed to fit securely on a pallet rail 726, as illustrated in Figure 12B, so that devices, such as a cable 724, can be attached to the pallet rail clip 728. In one embodiment, pallet rail clip 728 fits into pallet rail 720 by pulling it or pushing it in place and sliding it sideways. More than one pallet rail clip 728 may be placed on a pallet rail 726.

One advantage of using a pallet rail clip 728 is convenience. For example, a cargo handler may be required to place a transponder 10 only on certain containers 200D on a pallet 720 that are of higher value or significance. Since pallet rail clip 728 can be secured to a pallet rail 720 quickly and in a secure manner, a supply of pallet rail clips 728, that contain transponder 10, may be made available and easily accessible for placing onto pallets 720 whenever required. Adhesives or other securing compounds are also not required to attach transponder 10 to pallet 270.

Pallet rail clip 728 may contain a clamp 729 that closes together to fit around an opening in pallet rail 726 to attach securely. Slot 300E is formed inside clamp 729 when clamp 729 is closed. Slot 300E may be a circular, elliptical, square or rectangular shape. Slot 300E may be closed if clamp 729 fully closes together, or slot 300E may be open if clamp 729 does not fully close. Slot 300E has a small aspect ratio for most slot antennas 16D. The aspect ratio if the width of slot 300E as compared to the length of slot 300E. However, slot 300E radiates electro-magnetic energy effectively despite the aspect ratio is close together.

In one embodiment, slot 300E is approximately 21 millimetres in length. Pallet rail clip 728 may also contain ring 729 inside clamp 730 for attaching cable 724 or other securing means. Some pallet rail clips 728 may also contain an optional lock 731, so that clamp 730 cannot be opened unless lock 731 is opened by key or other means, such as a security combination.

Figure 12C illustrates transponder 10, previously described and illustrated in Figure 3, attached to pallet rail clip 728 to provide wireless communication between pallet 720 and interrogation reader 50. Transponder 10 may have a variety of information concerning containers 200D contained on pallet 720 that is communicated

wirelessly to interrogation reader 50, such as type, quantity, "born-on" date or date of manufacture, lot number, destination, etc.

Conductive tabs 100A, 100B are coupled to opposite sides of slot 300E to form a slot antenna 16E. When voltage signals are provided by transponder 10 to the edges of slot 300E, slot 300E radiates electro-magnetic waves similar to the manner in which a pole antenna arrangement would radiate to effectuate wireless communications. In one embodiment, two conductive tabs 100A, 100B are 3 millimetres in length, and are coupled across slot 300E that is 21 millimetres in length. This configuration provides transponder 10 slot antenna 16E at an operating frequency of 2.45 GHz. The radiation pattern of slot antenna 16E when two conductive tabs 100A, 100B are coupled to slot 300E is similar to the radiation pattern of a dipole antenna, with the E and H fields are reversed. Slot antenna 16D may also be provided by one conductive tab 100 coupled to transponder 10 and slot 300E. The radiation pattern of slot antenna 16E when one conductive tab 100 is coupled to slot 300E will is similar to the radiation pattern of a monopole antenna, with the E and H fields reversed. Pallet rail clip 728 may also be used by transponder 10 as a ground plane if transponder 10 is coupled to a conductive portion of pallet rail clip 728.

Pallet Rail Slot Antenna

Figures 13A and 13B illustrate another embodiment of placing transponder 10 on pallet 270. As previously discussed, pallet 270 may have one or more pallet rails 726 attached to act as securing means for pallet rail clips 728 or other devices and cables 724, or the like. Pallet rail 726 has a grove that forms slot 300F. Slot 300F is unbounded and is of a varying width, formed by a series of ridges 727 that run

continuously through pallet rail 726. Ridges 727 protrude out from backplane 733 and protrude downward.

Transponder 10 is coupled to two conductive tabs 100A, 100B. Two conductive tabs 100A, 100B are coupled across slot 300F formed by protruding ridges 727 from backplane 733. In this manner, transponder 10 uses slot 300F as a slot antenna 16F to communicated wirelessly with interrogation reader 50, with slot antenna 16F having a radiation pattern similar to a dipole antenna, as previously discussed. Conductive tabs 100A, 100B are coupled across the center of slot 300F, or at on an offset of center of slot 300F. Conductive tabs 100 may contain and adhesive, so that transponder 10 attaches to pallet rail 726 in a secure manner. In addition, transponder 10 may have one conductive tab 100 coupled to slot 300F to form slot antenna 16F. In this manner, slot antenna 16F has a radiation pattern similar to a monopole antenna, as previously discussed. Backplane 733 may also be used as a ground plane for transponder 10. Transponder 10 may communicate at 2.45 GHz, 915 MHz, or other frequency.

An alternative embodiment is to provide a bounded slot 300F on pallet rail 726. Figure 13B illustrates transponder 10 attached to pallet rail 726 that is essentially the same as illustrated in Figure 13A. However, a foil frame 732 is provided on pallet rail 726 to bound or limit the length of slot 300F. Foil frame 732 is a conductive material, and made be constructed out of aluminum, copper or other conductive material. When foil frame 732 is placed across slot 300F, the length of slot 300F becomes the length of foil frame 732, since the outer edges of foil frame 732 keep current from conductive tabs 100A, 100B from running down the entire length of pallet rail 726. In one embodiment, the length of slot 300F, as bounded by foil frame 732, is 22 millimeters, and the width of slot 300F, as bound by foil frame 732, is 20 millimeters. Foil frame

732 may also contain an adhesive material to attach to pallet rail 726. Adhesive 102 may or may not be a dielectric.

Figures 14A and 14B illustrate another embodiment of providing transponder 10 on pallet rail 726 using a feed line 740 to couple transponder 10 to slot 300G. In Figure 14A, transponder 10 is placed on the solid portion of pallet rail 726. Feed line 740 provides a direct electrical connection between transponder 10 and slot 300G. In this manner, slot 300G radiates electro-magnetic energy from transponder 10 to form slot antenna 16F.

Figure 14B illustrates an embodiment whereby feed line 740 from transponder 10 does not directly connect to slot 300G. Instead, feed line 740 is placed in close proximity to slot 300G to reactively couple to slot 300G. Slot 300G still receives radiated energy from transponder 10, through feed line 740, due the close proximity of feed line to slot 300G.

Pallet Tracking

Figure 15 illustrates a tracking system in which pallets 720, containing a transponder 10, may be tracked through an environment such as a factory, storage, distribution, or other facility. For example, pallet 270 may pass a first interrogation point 752 that includes an interrogation reader 50. When pallet 720, and specifically its transponder 10, is in the presence of the interrogation reader 50 as previously described, a message containing information and/or a specific request for information may be transmitted by interrogation reader 50 and received by the transponder 10. This process continues as the pallet 270 moves to a second interrogation point 754, a third interrogation point 756, a fourth interrogation point 758, and on to a last interrogation

point 760. However, please note that a tracking system may contain more or less interrogation points that illustrated in Figure 15.

A central control system 750 maintains the information from interrogation readers 50 and monitors the movement of pallets 270 through the facility. The information received by each of interrogation readers 40 may be forwarded to the central control system 100 either through direct wiring or LAN connection, and such wiring protocol may be any type, including parallel or serial. Central control system 750 may also send information to interrogation reader 50 to be transmitted to the pallet 270 for identification purposes. Central control system 750 may track the expected location of pallets 750 and may be alerted if it expects to receive information about a particular pallet 750 at a given time and does not.

During commissioning of each pallet 750 containing a transponder 10, it may be necessary to place transponder 10 in range of interrogation reader 50 in order to erase previously stored information in memory 18 or to store particular data or configuration information about pallet 750 and/or its containers 200C in memory 18 for later use.

Claims:

1. A communication device for attachment to a pallet to communicate information concerning items contained on the pallet, said device comprising: a pallet rail clip for attachment to the pallet; a wireless communication device attached to said clip; and an antenna coupled to said wireless communication device.

2. A device according to claim 1, wherein said antenna is a slot antenna.

3. A device according to claim 2, wherein said slot antenna is formed by a slot in said pallet rail clip.

4. A device according to claim 3, wherein said slot is circular in shape.

5. A device according to claim 3, wherein said slot is 21 mm in length.

6. A device according to claim 3, wherein said antenna is formed by at least one conductive tab coupled to said slot.

7. A device according to claim 6, wherein said at least one conductive tab is two conductive tabs, said two conductive tabs being coupled across said slot.

8. A device according to claim 1, wherein said antenna is formed by at least one conductive tab coupled to said wireless communication device.

9. A device according to claim 8, wherein said at least one conductive tab is two conductive tabs.

10. A device according to claim 8, wherein said at least one conductive tab is capable of communicating in a first mode as a slot antenna and in a second mode as a pole antenna.

11. A device according to claim 8, wherein said at least one conductive tab contains an adhesive.

12. A device according to claim 1, wherein said wireless communication device communicates at a frequency of 915 MHz or 2.45 GHz.

13. A wireless communication system for communicating information concerning items contained on a pallet, said system comprising: a pallet; a wireless communication device attached to said pallet; and an antenna coupled to said wireless communication device, said wireless communication device communicating said information concerning items contained on said pallet.

14. A system according to claim 13, wherein said antenna is a slot antenna.

15. A system according to claim 14, wherein said slot antenna is formed by said wireless communication device coupled to a slot on said pallet.

16. A system according to claim 15, further comprising at least one feed line coupling said wireless communication device to said slot to form said slot antenna.

17. A system according to claim 15, wherein said wireless communication device is coupled to at least one conductive tab.

18. A system according to claim 17, wherein said at least one conductive tab is coupled across said slot to form said slot antenna.

19. A system according to claim 17, wherein said wireless communication device is coupled to a ground plane on said pallet.

21. A system according to claim 17, wherein said at least one conductive tab is two conductive tabs.

22. A system according to claim 21, wherein said two conductive tabs are coupled across said slot to form said slot antenna.

23. A system according to claim 15, wherein said wireless communication device is coupled to a foil frame that is attached to said slot to bound said slot.

24. A system according to claim 15, wherein said slot is bounded.

25. A system according to claim 15, wherein said slot is continuous.

26. A system according to claim 15, wherein said slot is contained in at least one pallet rail placed on said pallet.

27. A system according to claim 26, wherein said at least one pallet rail is a plurality of pallet rails connected together and attached on all sides of said pallet.

28. A system according to claim 27, wherein said slot is bounded.

29. A system according to claim 27, wherein said slot is continuous.

30. A system according to claim 27, wherein said slot varies in width.

31. A system according to claim 27, wherein said slot is of substantially constant width.

32. A system according to claim 27, wherein said wireless communication device is coupled to a ground plane on said pallet rail.

33. A system according to claim 27, further comprising at least one feed line coupling said wireless communication device to said slot to form said slot antenna.

34. A system according to claim 27, wherein said wireless communication device is coupled to at least one conductive tab.

35. A system according to claim 34, wherein said at least one conductive tab is coupled across said slot to form said slot antenna.

36. A system according to claim 34, wherein said at least one conductive tab is two conductive tabs.

37. A system according to claim 36, wherein said two conductive tabs are coupled across said slot to form said slot antenna.

38. A system according to claim 27, wherein said wireless communication device is coupled to a foil frame that is attached to said slot to bound said slot.

39. A system according to claim 38, wherein said foil frame contains an adhesive.

40. A system according to claim 34, wherein said at least one conductive tab is 10mm in length.

41. A system according to claim 13, wherein said pallet is an air-cargo pallet.

42. A system according to claim 34, wherein said at least one conductive tab is capable of communicating in a first mode as a slot antenna and in a second mode as a pole antenna.

43. A system according to claim 34, wherein said at least one conductive tab contains an adhesive.

44. A system according to claim 13, wherein said wireless communication device communicates at a frequency of 2.45 GHz or 915 MHz.

45. A method of providing wireless communication on a pallet containing a pallet rail, said method comprising: attaching a wireless communication device to a stud clip by coupling said wireless communication device across a slot in said stud clip; and attaching said stud clip to said pallet rail.

46. A method according to claim 45, further comprising locking said stud clip to the pallet rail.

47. A method according to claim 45, further comprising coupling at least one conductive tab coupled to said wireless communication device across said slot.

48. A method according to claim 45, further comprising grounding said wireless communication device to said stud clip.

49. A method of providing wireless communication on a pallet, said method comprising: placing a slot in the pallet; and attaching a wireless communication device to the pallet by coupling said wireless communication device to said slot to provide a slot antenna.

50. A method according to claim 49, wherein said placing a slot comprises attaching a pallet rail having a slot to the pallet.

51. A method according to claim 50, further comprising coupling at least one conductive tab coupled to said wireless communication device across said slot.

52. A method according to claim 50, further comprising coupling at least one feed line coupled to said wireless communication device to said slot.

53. A method according to claim 50, further comprising bounding the width of said slot.

54. A method according to claim 50, further comprising attaching more than one said pallet rail to the pallet.

55. A method according to claim 49, wherein said attaching a wireless communication device to the pallet further comprises placing an adhesive on said wireless communication device.

56. A method of tracking a pallet, said method comprising: attaching a wireless communication device to the pallet; moving the pallet through at least one interrogation point containing an interrogation reader; and communicating tracking information associated with the pallet between said wireless communication device and said interrogation reader through a slot antenna formed by a slot on the pallet.

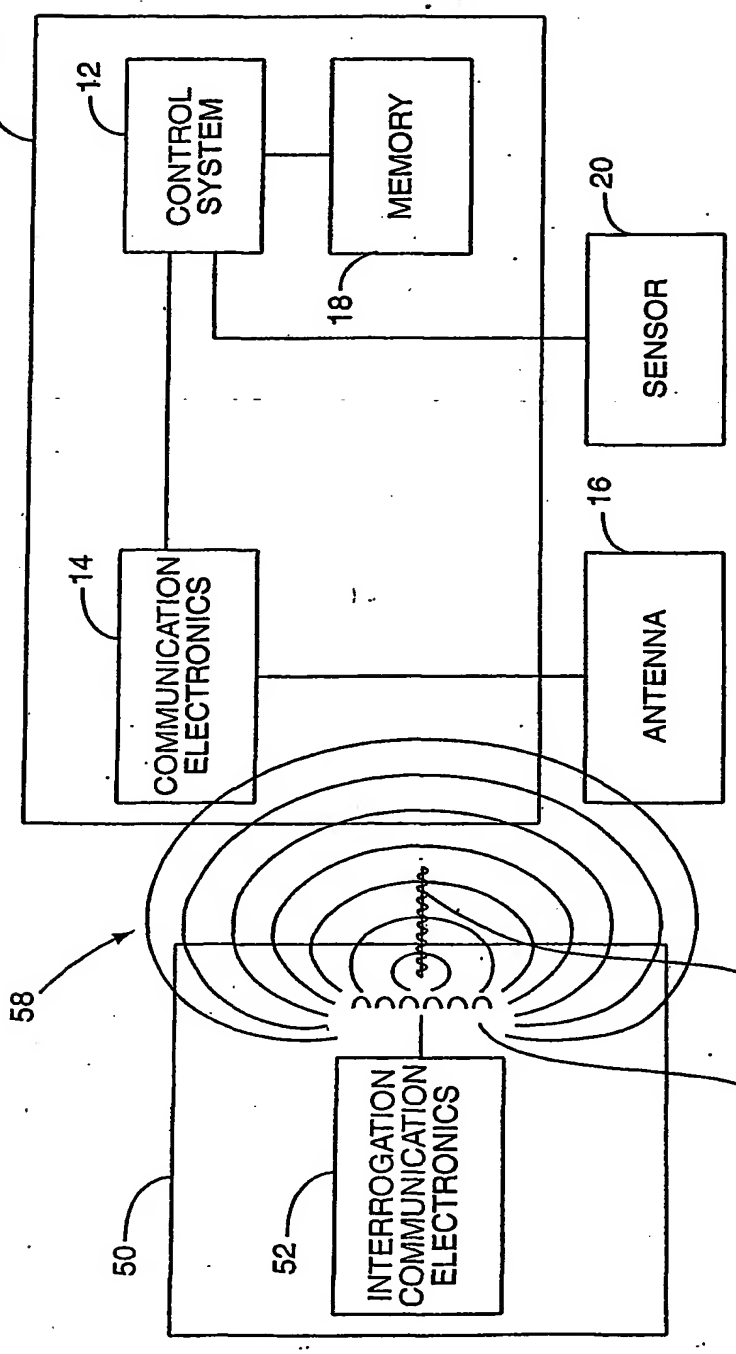

FIG. 1

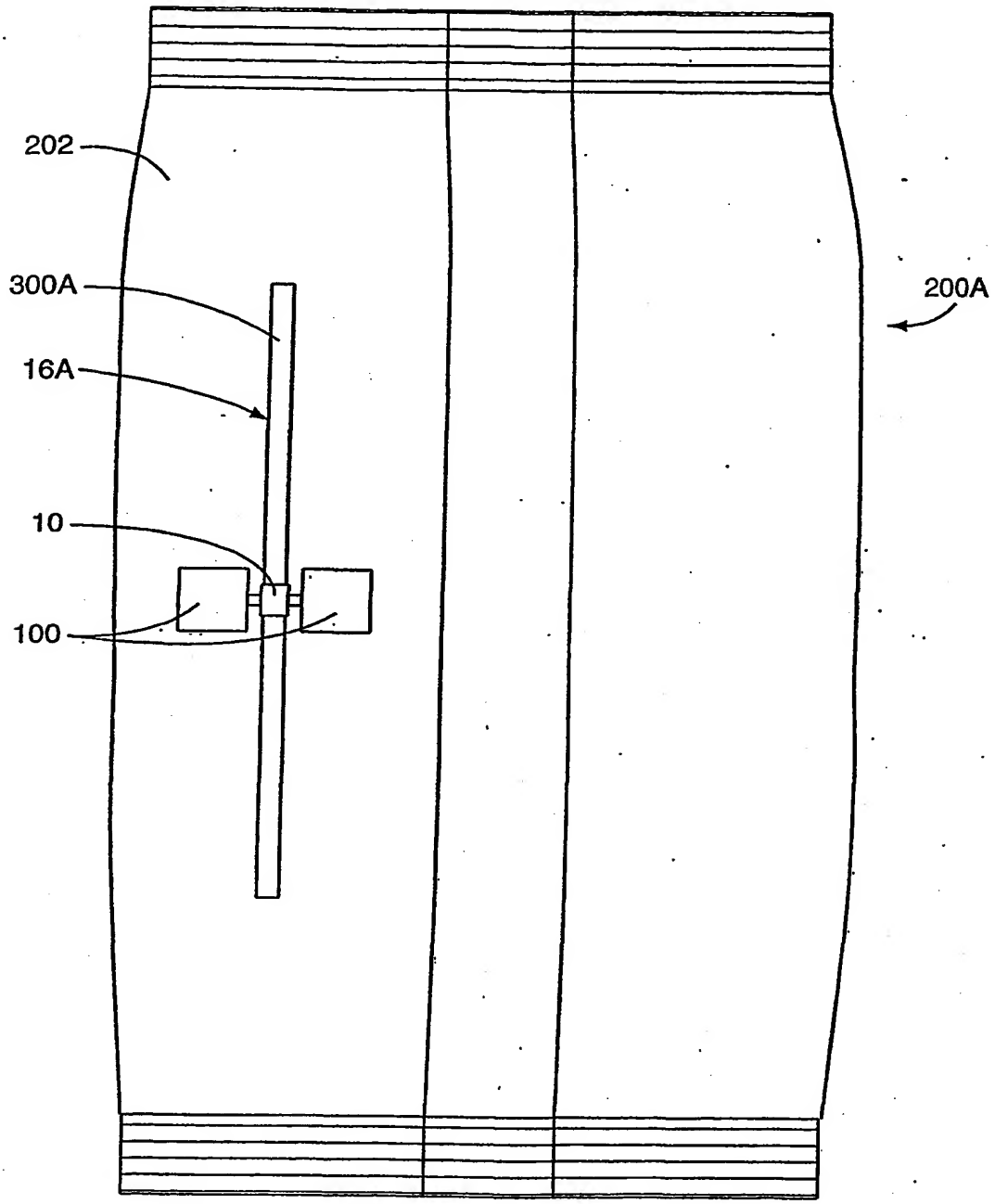

FIG. 2

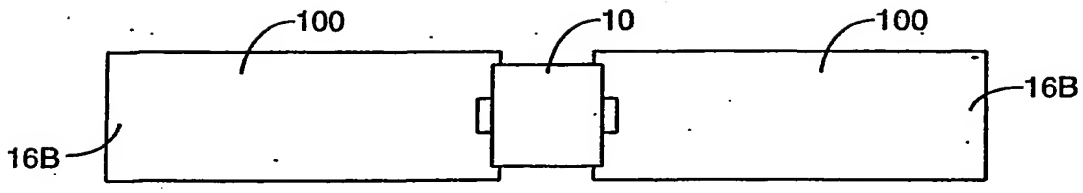

FIG. 3A

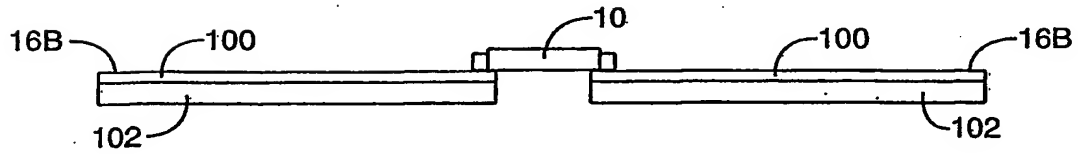

FIG. 3B

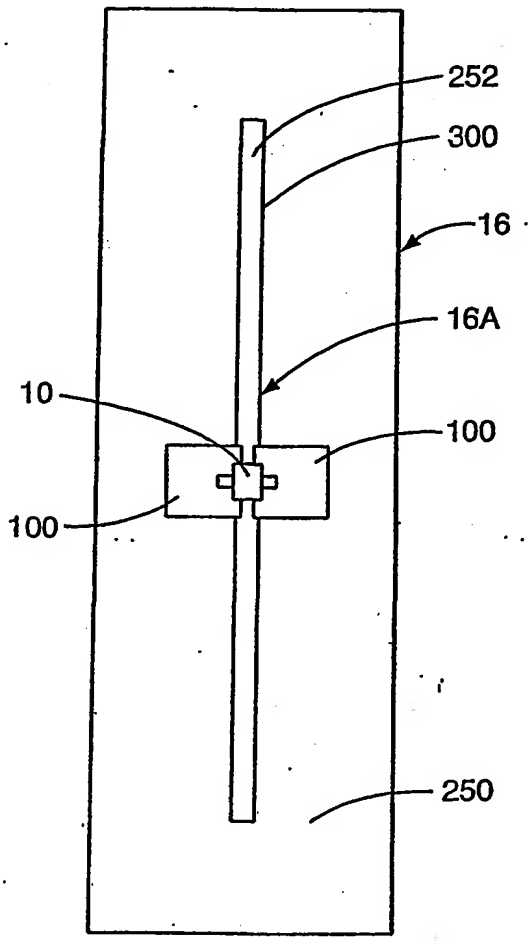

FIG. 3C

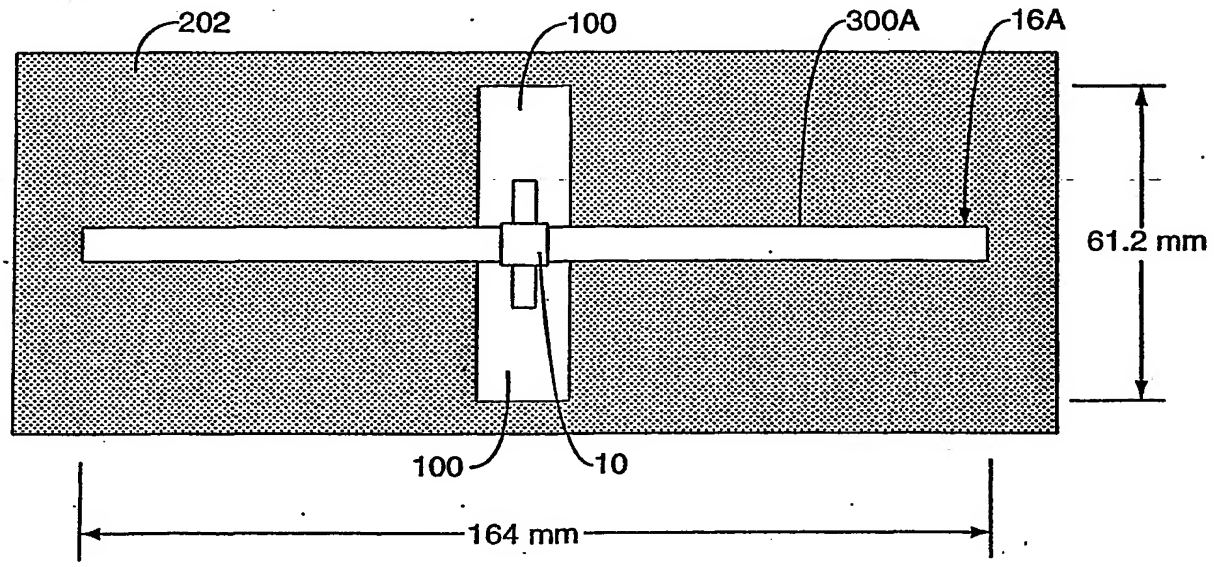

FIG. 4

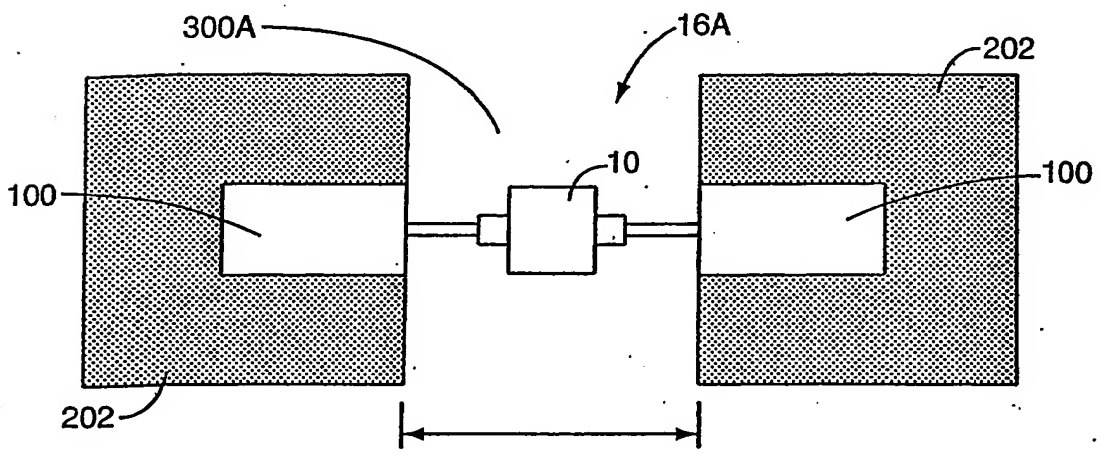

FIG. 5A

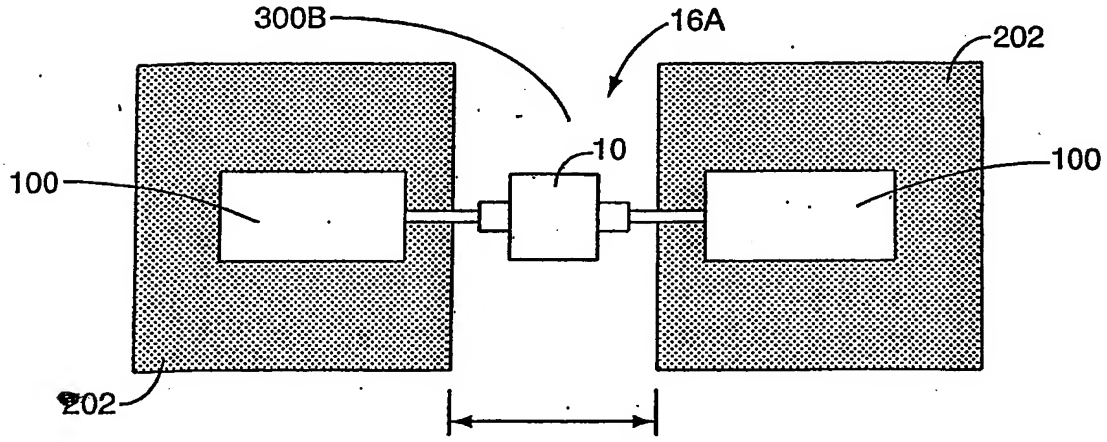

FIG. 5B

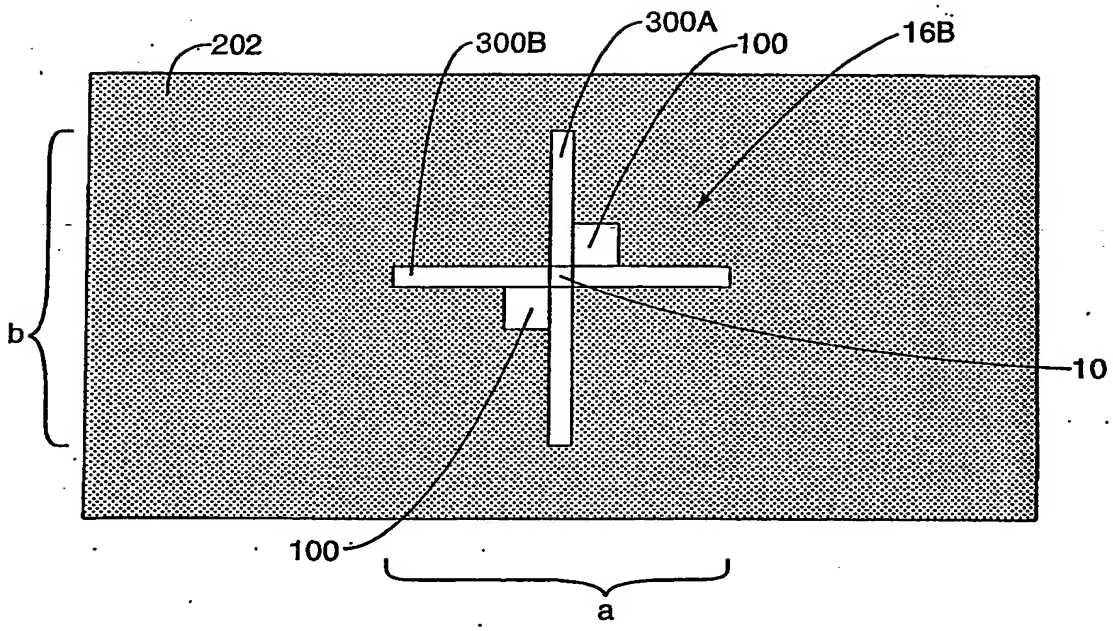

FIG. 6

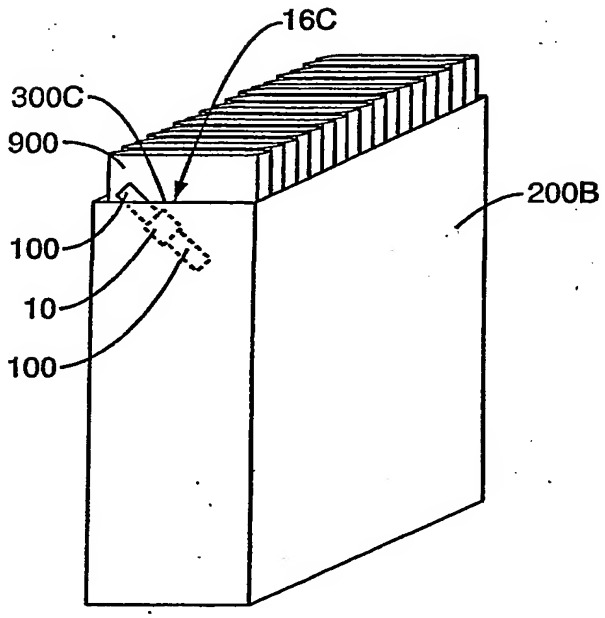

FIG. 7

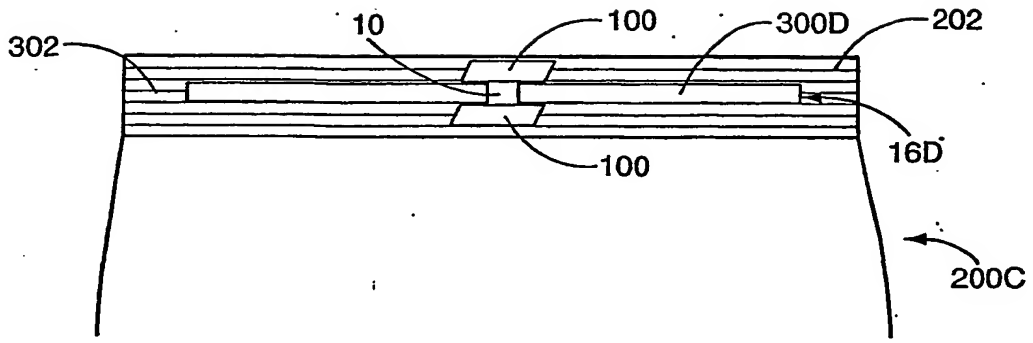

FIG. 8A

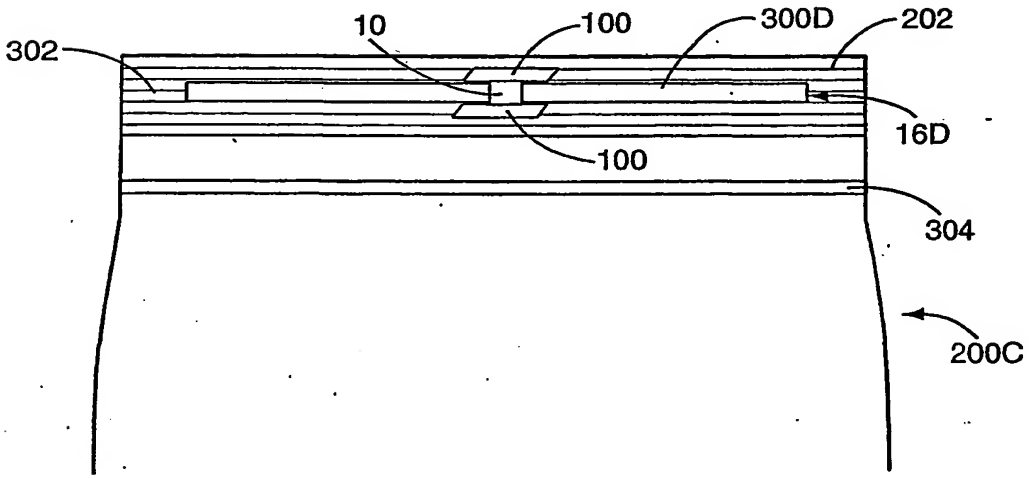

FIG. 8B

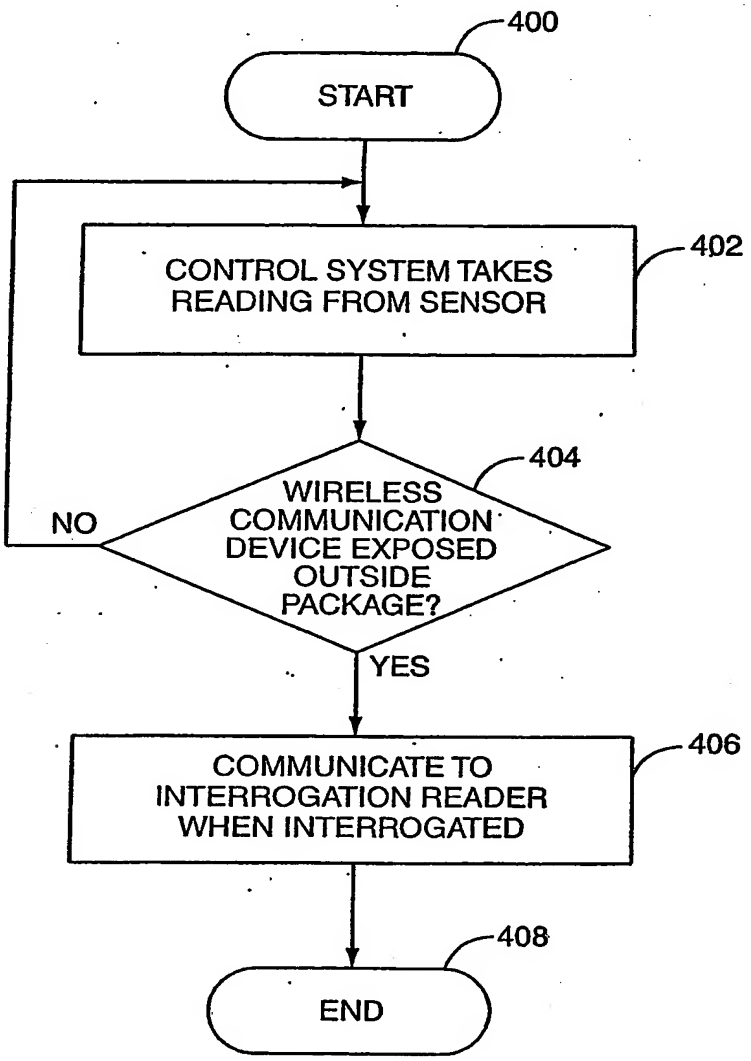
400
START
CONTROL SYSTEM TAKES READING FROM SENSOR
402
404
WIRELESS COMMUNICATION DEVICE EXPOSED OUTSIDE PACKAGE?
NO
YES
COMMUNICATE TO INTERROGATION READER WHEN INTERROGATED
406
408
END

FIG. 9

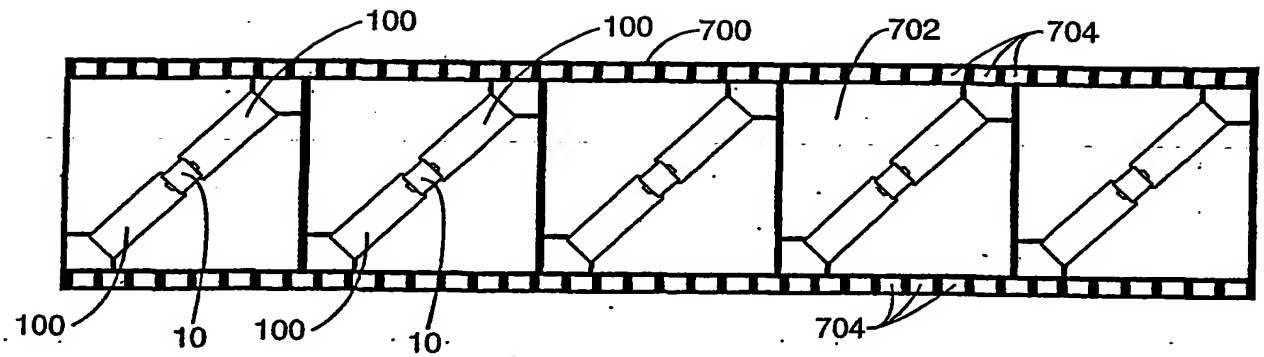

FIG. 10

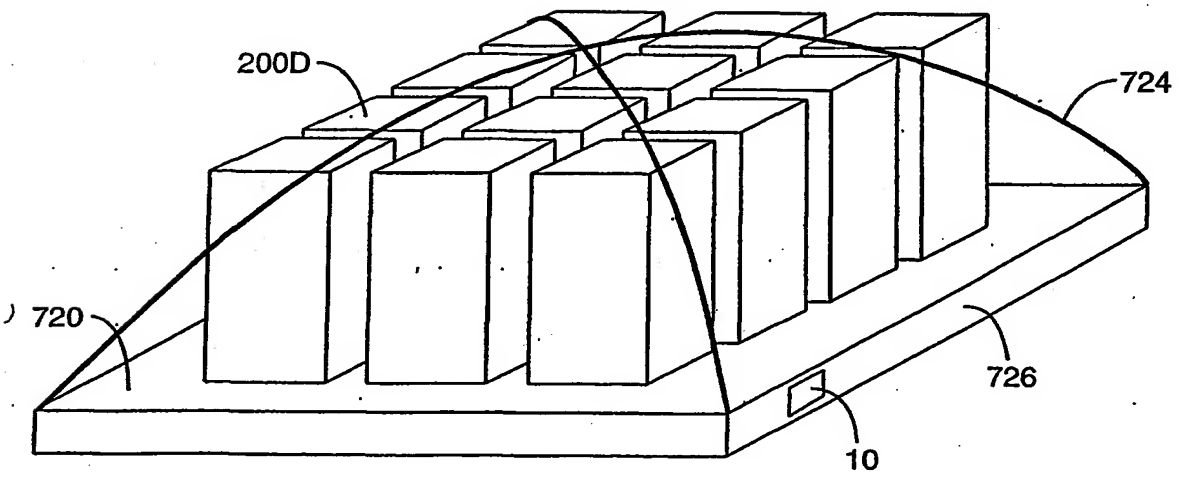

FIG. 11

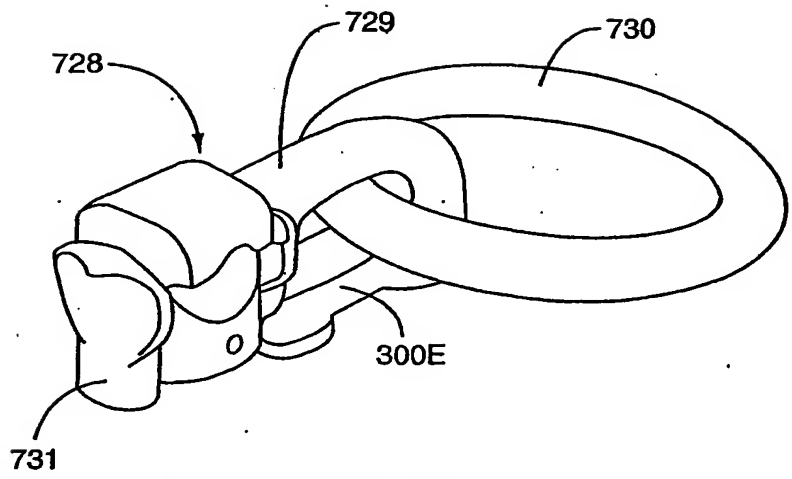

FIG. 12A

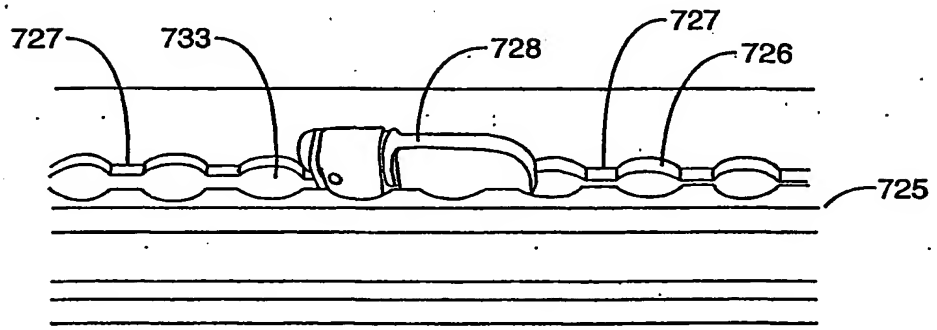

FIG. 12B

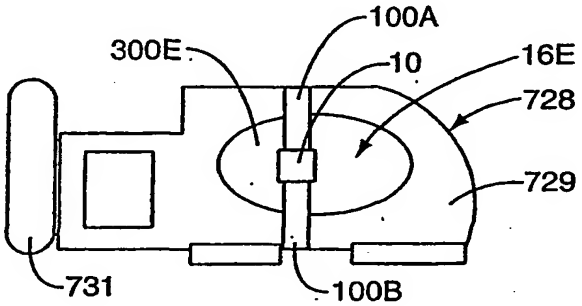

FIG. 12C

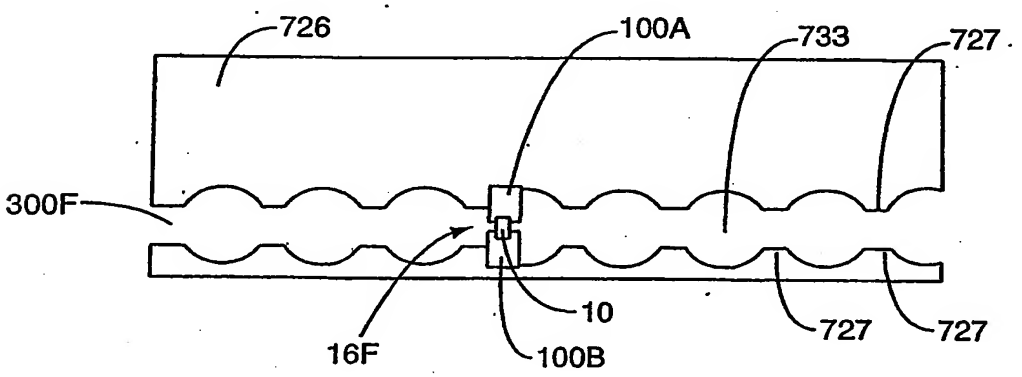

FIG. 13A

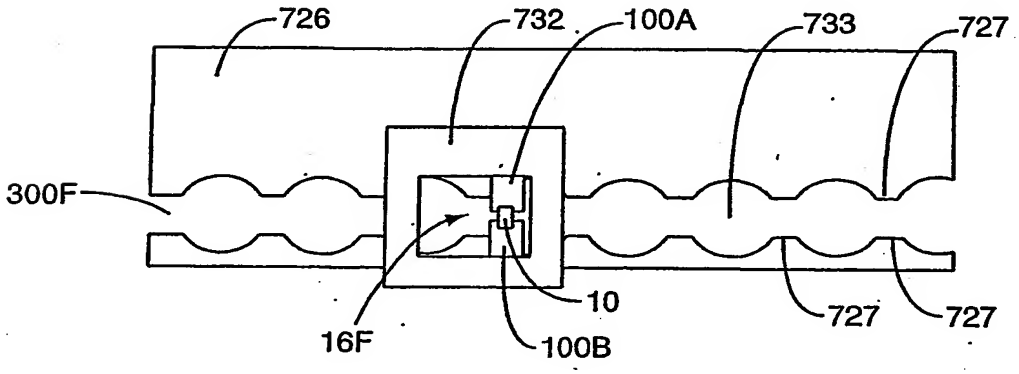

FIG. 13B

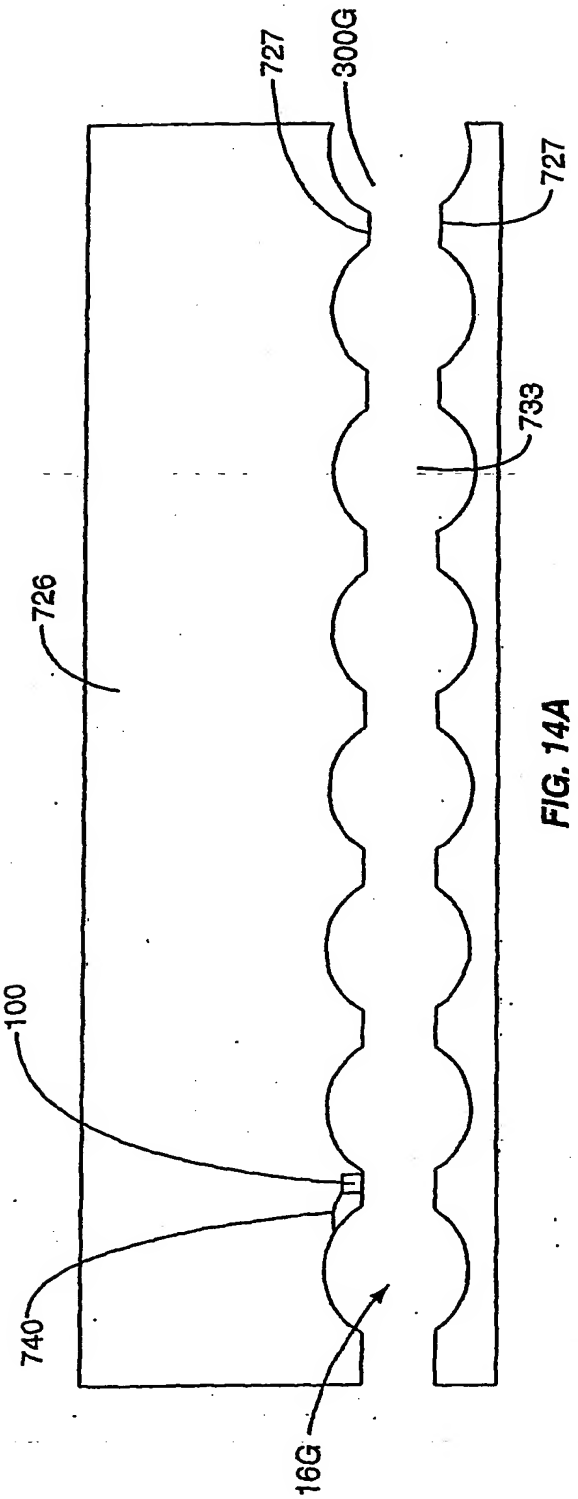

FIG. 14A

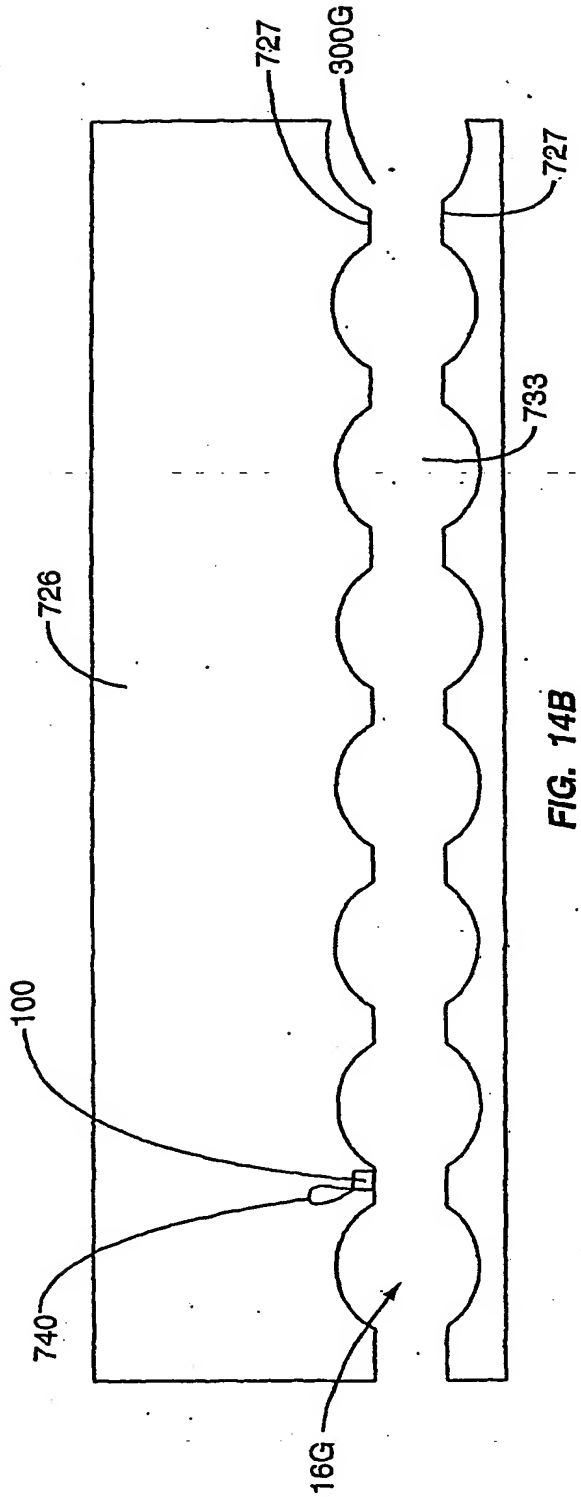

FIG. 14B

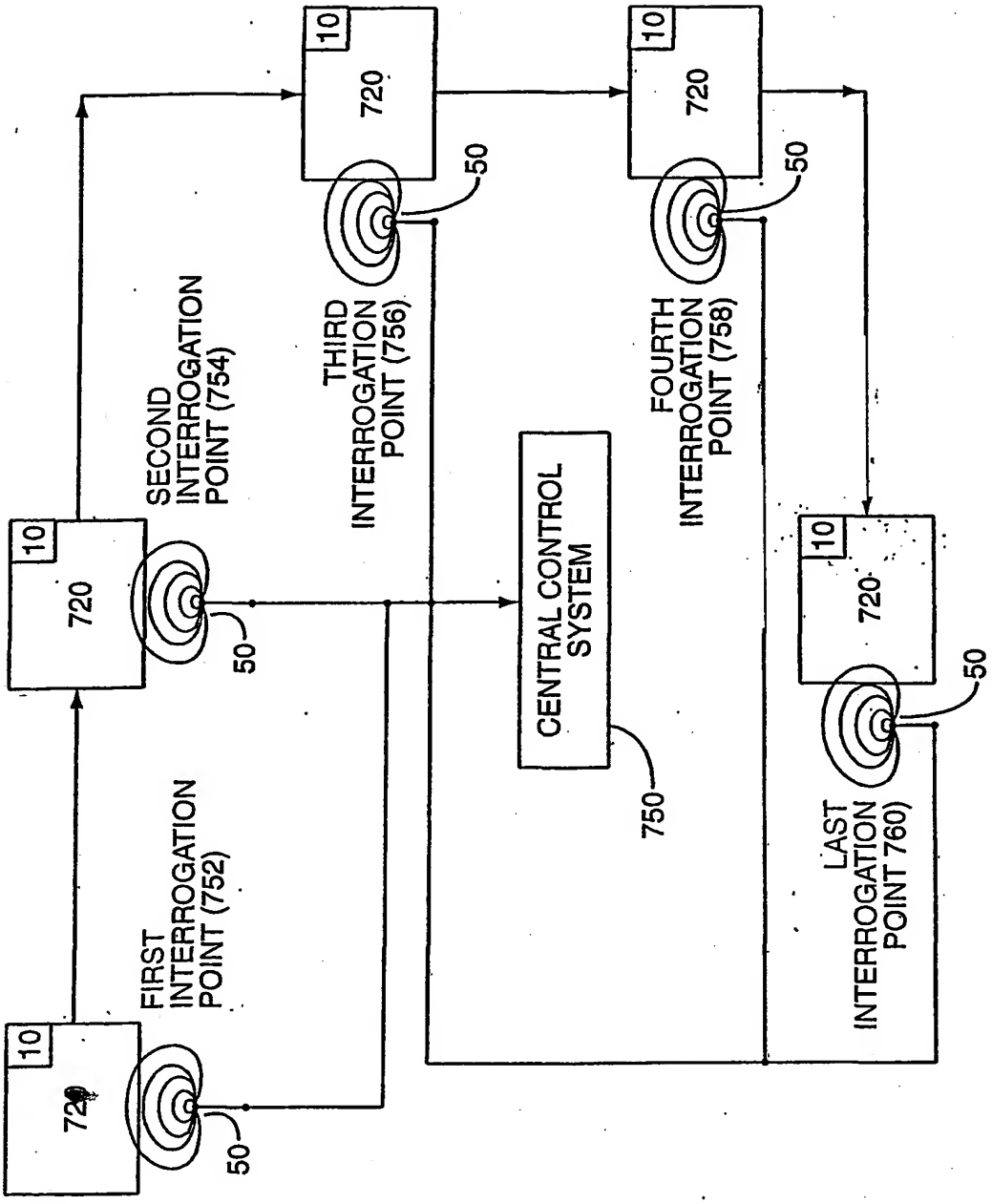

FIG. 15

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/03223

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06K19/077 G06K19/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 697 801 A (ALLIBERT EQUIPEMENT) 13 May 1994 (1994-05-13)	13,45
A	claims 1,2,4,6	46
X	FR 2 706 422 A (ESOR SARL) 23 December 1994 (1994-12-23) claims 1,3	13
X	WO 99 65002 A (MOTOROLA INC) 16 December 1999 (1999-12-16) claims 1,8	13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 November 2001	04/12/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Herskovic, M

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 05, 31 May 1999 (1999-05-31) & JP 11 035038 A (NIIGATA ENG CO LTD), 9 February 1999 (1999-02-09) abstract	1,45
A	"MULTI-PURPOSE TOTE AND INSERTION SYSTEM FOR GENERIC MATERIAL HANDLING" IBM TECHNICAL DISCLOSURE BULLETIN, IBM CORP. NEW YORK, US, vol. 31, no. 6, 1 November 1988 (1988-11-01), pages 314-315, XP000051279 ISSN: 0018-8689 the whole document	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

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